USGS
science for a changing world

Pinson Valley PA
Ref 19

Prepared in cooperation with the City of Tarrant, Alabama

Simulation of Flood Profiles for Fivemile Creek at Tarrant, Alabama, 2006

Open-File Report 2007–1030

U.S. Department of the Interior
U.S. Geological Survey

Cover. *May 7, 2003, flood in the City of Tarrant, Alabama.* (Photographed by Fire Chief Billy Hewitt of the City of Tarrant and used with permission.)

Simulation of Flood Profiles for Fivemile Creek at Tarrant, Alabama, 2006

By K.G. Lee and T.S. Hedgecock

Prepared in cooperation with the City of Tarrant, Alabama

Open-File Report 2007–1030

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2007

For product and ordering information:
World Wide Web: [illegible]
Telephone: [illegible]

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment:
World Wide Web: [illegible]
Telephone: [illegible]

Suggested citation:
[illegible], 2007, [illegible]: U.S. Geological Survey Open-File Report 2007–[illegible], 25 p.

Contents

Figures

Tables

Conversion Factors and Datums

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Hydraulic gradient	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Simulation of Flood Profiles for Fivemile Creek at Tarrant, Alabama, 2006

By K.G. Lee and T.S. Hedgecock

Abstract

A one-dimensional step-backwater model was used to simulate flooding conditions for Fivemile Creek at Tarrant, Alabama. The 100-year flood stage published in the current flood insurance study for Tarrant by the Federal Emergency Management Agency was significantly exceeded by the March 2000 and May 2003 floods in this area. A peak flow of 14,100 cubic feet per second was computed by the U.S. Geological Survey for the May 2003 flood in the vicinity of Lawson Road. Using this estimated peak flow, flood-plain surveys with associated roughness coefficients, and the surveyed high-water profile for the May 2003 flood, a flow model was calibrated to closely match this known event. The calibrated model was then used to simulate flooding for the 10-, 50-, 100-, and 500-year recurrence interval floods.

The results indicate that for the 100-year recurrence interval, the flood profile is about 2.5 feet higher, on average, than the profile published by the Federal Emergency Management Agency. The absolute maximum and minimum difference is 6.80 feet and 0.67 foot, respectively. All water-surface elevations computed for the 100-year flood are higher than those published by the Federal Emergency Management Agency, except for cross section H. The results of this study provide the community with flood-profile information that can be used for existing flood-plain mitigation, future development, and safety plans for the city.

Introduction

Effective flood-plain management and planning depend on the accurate determination of flood profiles. In most cases, the application of a hydrologic and hydraulic model is necessary in the computation of flood profiles. Construction in flood-prone areas is a major concern of the City of Tarrant (formerly Tarrant City), Alabama. Tarrant is primarily an industrial town and is located in the Fivemile Creek basin. Since 1980, urban development has been based on existing profiles published by the Federal Emergency Management Agency (FEMA). Originally, these profiles were based on conditions reflective of 1979 (Federal Emergency Management Agency, 1980). In 1998, the FEMA flood profiles were revised in this reach and published in a later report (Federal Emergency Management Agency, 1999).

Since the completion of the 1999 FEMA study, the basin has experienced increased urbanization affecting the flooding potential of Fivemile Creek. The U.S. Geological Survey (USGS), in cooperation with the City of Tarrant, revised the hydrology and flood profiles for a reach of Fivemile Creek that is about 20,000 feet (ft) long to accurately depict the current and future flooding potential. These flood profiles are designed to aid Tarrant's engineers and planners with decisions concerning existing flood-plain mitigation, future development, and safety plans for the city.

Purpose and Scope

The objective of this report is to document the results of an investigation to determine the flood profiles for a reach of Fivemile Creek that is about 20,000 ft long. This reach extends from about 300 ft upstream from Lawson Road downstream to just below the L&N Railroad near Boyles Gap (fig. 1). Flood profiles were developed for the 10-, 50-, 100-, and 500-year floods using hydrologic and hydraulic models. Prior to the development of these profiles, the hydraulic model was calibrated to match the May 7, 2003, flood in order to apply the model to other flooding scenarios. The flood-profile information in this report can be used by the community for future planning and design purposes.

Description of the Study Reach

The City of Tarrant is located in north central Alabama, approximately 1.5 miles northeast of Birmingham, in Jefferson County, Alabama (fig. 1). The average slope of the channel in the study reach is 18.5 feet per mile (ft/mi). The stream flows in a southwesterly direction and has an average bankfull width of 85 ft with minimum and maximum widths of 50 and 130 ft, respectively. Bankfull width is the width between the top of the left and right channel banks for a stream channel. The average flood-plain width is 1,000 ft and ranges from 200 to 2,000 ft. The land cover of the reach is characterized by grassy fields and wooded areas with moderate vegetative undergrowth. The reach extends through areas of residential and industrial land use. These areas typically have minimal or maintained vegetative growth and areas of ineffective flow

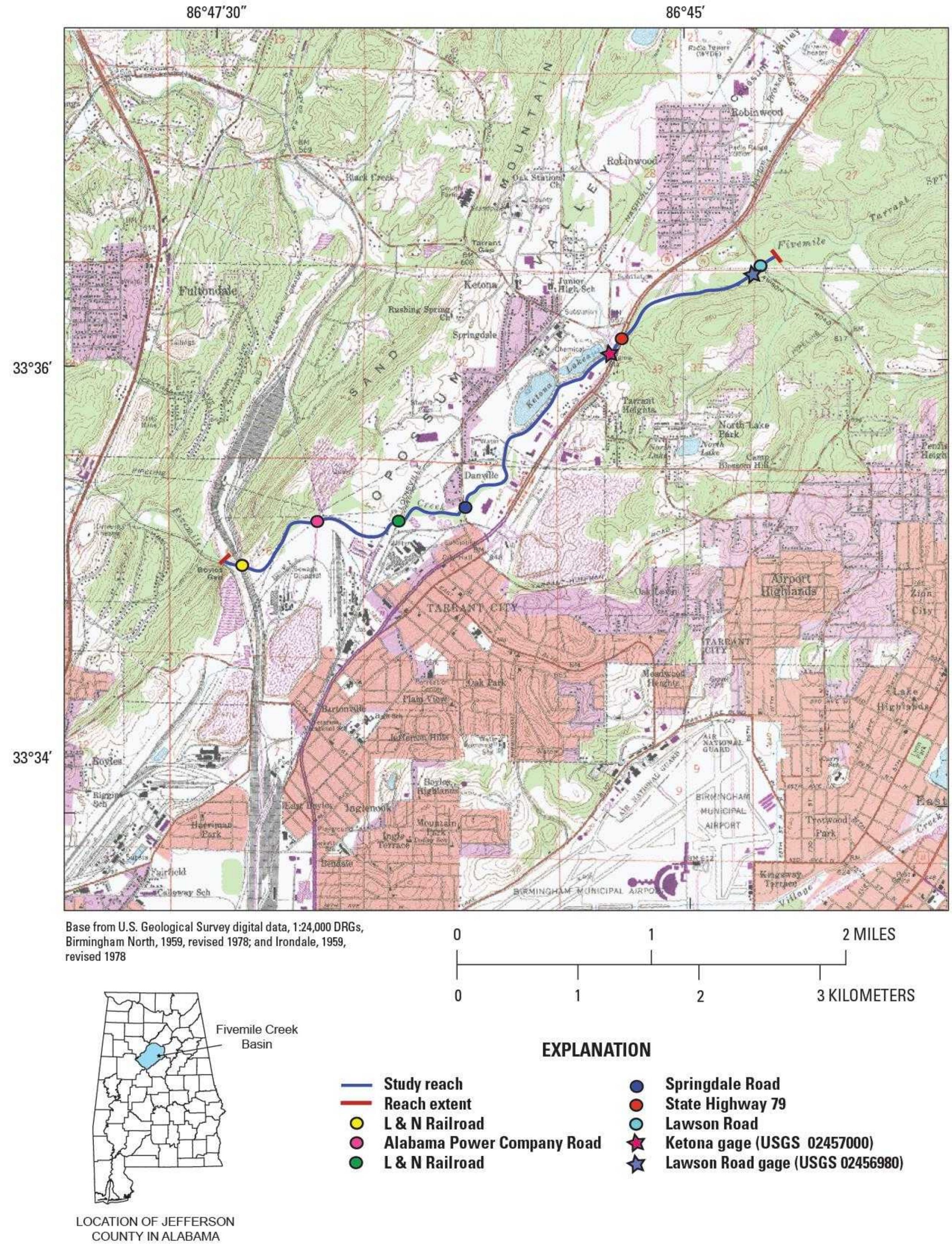

Figure 1. Fivemile Creek study reach, Tarrant, Jefferson County, Alabama.

Flood History

Anthropogenic changes in the Fivemile Creek basin have substantially altered the hydrologic and hydraulic conditions of the basin. On March 10, 2000, and May 7, 2003, the flood stage at the Ketona gage on Fivemile Creek in Tarrant (USGS gage 02457000) (fig. 1) exceeded the published 100-year flood stage of 561.2 ft (Federal Emergency Management Agency, 1999) by 2.8 ft and 4.6 ft, respectively. Both of these floods caused a considerable amount of damage to local residents and community businesses (Fire Chief Billy Hewitt, City of Tarrant, oral commun., 2004).

The study reach contains six hydraulic structures. Of the six structures, four were overtopped by the 2003 flood: Lawson Road, State Highway 79, Springdale Road, and the Alabama Power Company Road (fig. 1). Other roads within the city limits also were inundated (figs. 2–4), impeding the flow of traffic and causing substantial damage to local businesses.

Acknowledgments

Special thanks are given to Mayor Loxcil Tuck and Fire Chief Billy Hewitt of the City of Tarrant for their assistance in the initialization of this study. The assistance of Hillary Aten of the Cawaco Resource Conservation and Development Council is also greatly appreciated.

Approach

The creation of new flood profiles was accomplished through: (1) field data collection, (2) land-use (impervious cover) determinations, (3) hydrologic analyses, and (4) hydraulic modeling. Flood profiles were developed for the 10-, 50-, 100-, and 500-year floods using hydrologic and hydraulic models. Prior to the development of these profiles, the hydraulic model was calibrated to closely match the surveyed May 7, 2003, flood profile in order to increase the accuracy of the results provided by this study.

Data Collection

In order to accurately represent the stream-channel and flood-plain geometry of the reach, field surveys were conducted using an electronic total station. Eleven flood-plain cross sections were surveyed, and the geometry of all drainage structures and adjacent roadways was measured (figs. 5 and 6). The study reach included one culvert and five bridges. Eleven high-water marks from the May 7, 2003, flood also were surveyed by USGS personnel for model calibration purposes. These high-water marks define a 14,264-ft reach of the flood profile extending from river station 3,804 to 18,068. A river station was defined for each cross section, hydraulic structure,

Figure 2. May 7, 2003, flooding behind the City Hall in Tarrant, Alabama.

Figure 3. May 7, 2003, flooding on State Highway 79 in Tarrant, Alabama.

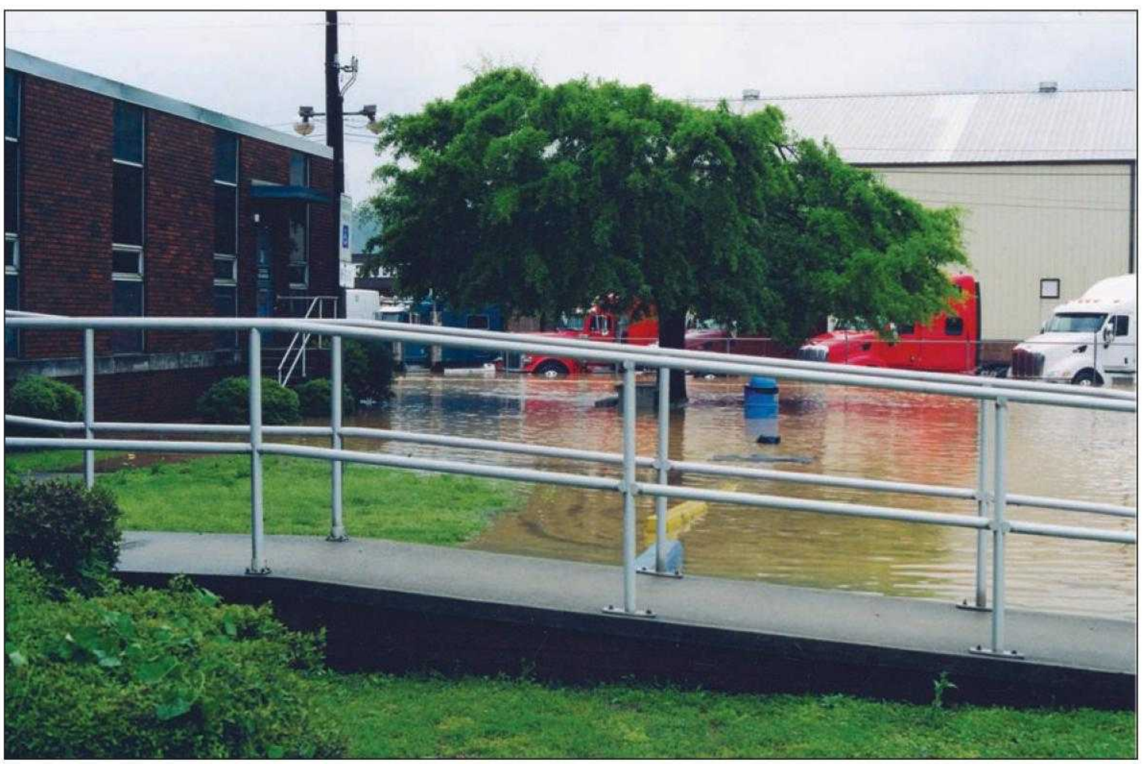

Figure 4. May 7, 2003, flooding at the City Hall in Tarrant, Alabama.

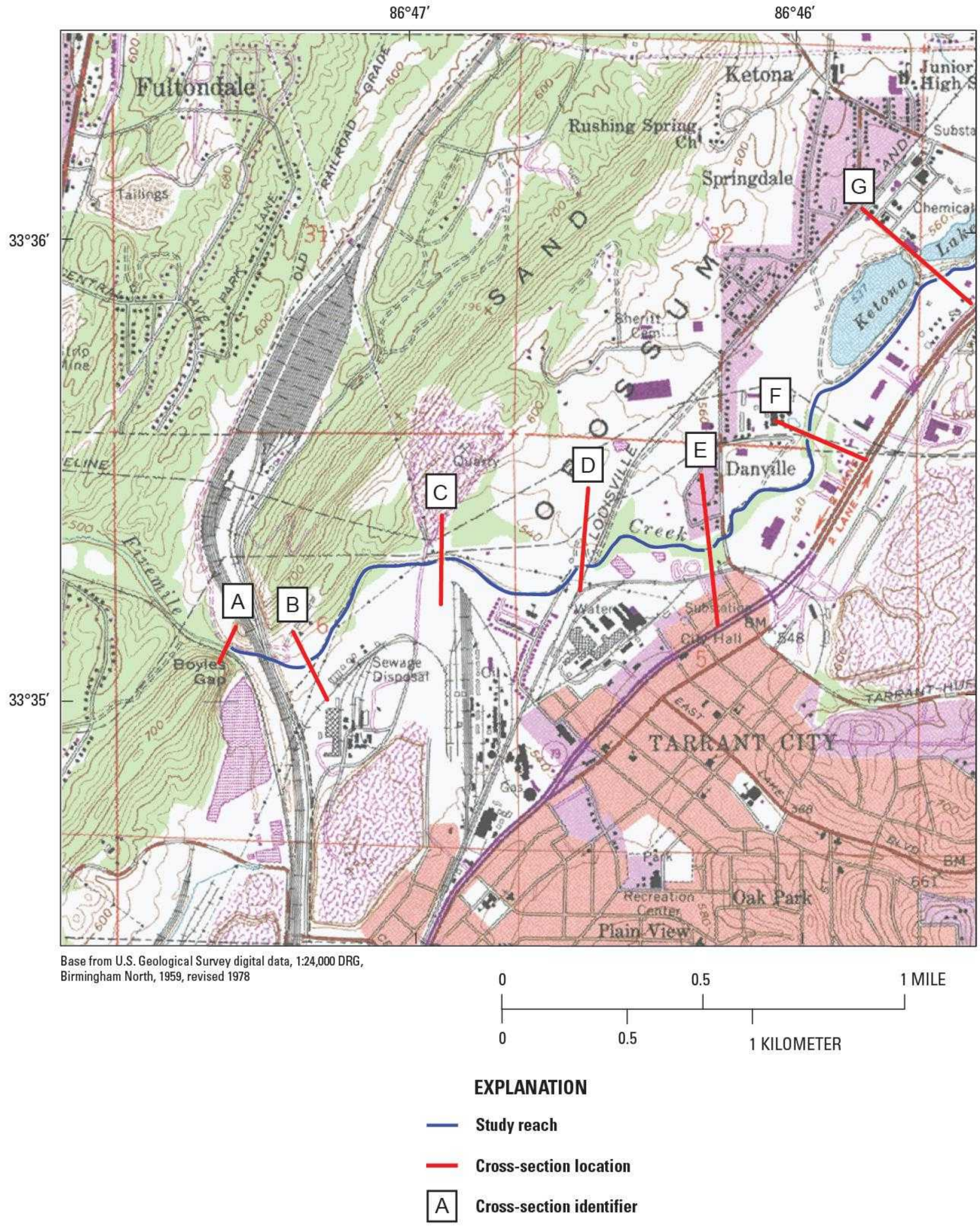

Figure 5. Approximate locations of cross sections A through G in the Fivemile Creek study reach.

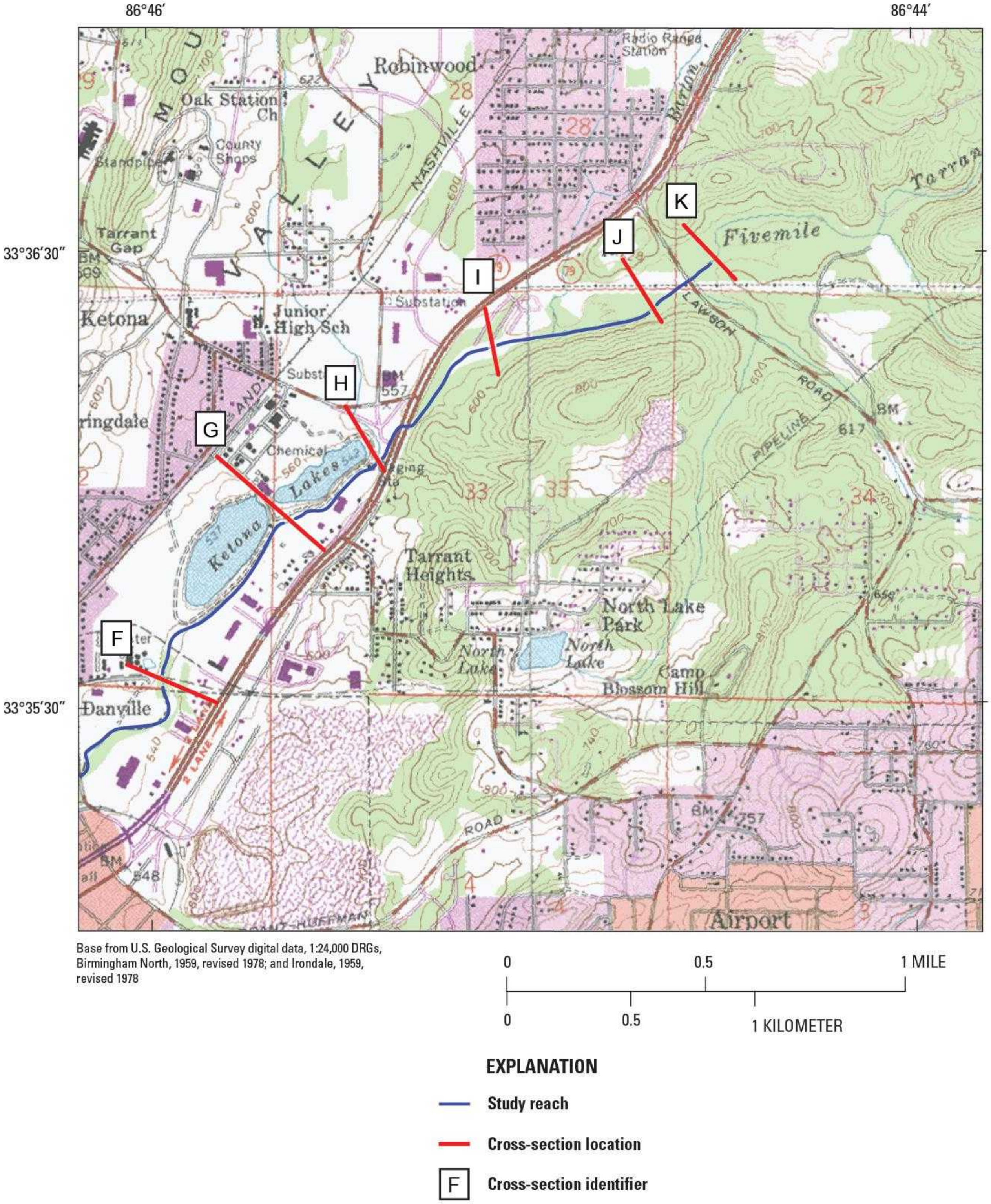

Figure 6. Approximate locations of cross sections F through K in the Fivemile Creek study reach.

and high-water mark. River-stationing for the study reach is arbitrary and is referenced from the downstream-most cross section (section A), which is river station 0.

Roughness characteristics for the reach were assessed from field investigations. Manning's roughness coefficients were selected to reflect current conditions and the conditions that existed during the 2003 flood. Manning's roughness coefficients and geometric conditions were calibrated to provide the best match to the surveyed 2003 flood profile. These hydraulic parameters were then adjusted slightly to reflect current conditions. Manning's roughness coefficients ranged from 0.05 to 0.065 for the channel and from 0.04 to 0.15 for the overbank areas. Photographs of the cross sections and the surrounding area are included in the Appendix as figures A1 through A13.

Land-Use Determination

Industrial and residential growth have contributed to substantial changes in the hydrologic conditions in the Fivemile Creek basin since 1992. In order to determine the peak flows that reflect current conditions, land use and impervious cover for the basin were calculated using the most recent aerial photographs available for the reach. These photographs were supplemented with surveys and field reconnaissance in the newer sections of development. Impervious cover of a basin is the percentage of total drainage area that is covered by buildings or pavement that are impenetrable by infiltration from rainfall. The percentage of impervious cover is an indication of the degree of development or urban land use of a basin (Stamper, 1975).

Aerial photography from 2004 was made available by the City of Tarrant for the entire drainage basin and was used to measure impervious areas. The percentage of impervious area was calculated to be approximately 20 percent, and 5 percent was added to account for future growth. The resulting value of impervious area used in the hydrologic model, for estimated future conditions, was 25 percent. The majority of the Fivemile Creek basin has been developed (fig. 7); therefore, the percentage of impervious area used in the hydrologic model should adequately represent the urban land use for future years. Based on the 2001 National Land Cover Dataset (NLCD) (Multi-Resolution Land Characteristics Consortium, 2006) and aerial photography (2004), the basin was estimated to be approximately 75 percent developed. The remaining 25 percent is located in flood-plain and ridge areas and has a low probability of development.

As mentioned earlier, the most recent floods greatly exceeded the theoretical 100-year flood profile developed by FEMA (1999). The higher-than-expected flood stages may be attributed to the recent growth experienced in the basin. In order to understand the magnitude of the modifications the basin has experienced, the percentage of impervious area was calculated for 1992, based on the availability of the NLCD (U.S. Geological Survey, 1992). This analysis was performed for the drainage area upstream from Boyles Gap. The results of the calculations show that in 1992, the basin had about 12 percent impervious area, whereas the 2004 conditions show that the basin had about 20 percent impervious area. In a period of 12 years, the percentage of impervious area almost doubled.

Hydrologic Analyses

Hydrologic analyses were conducted using the USGS urban regression equations and procedures outlined in "Synthesized Flood Frequency of Urban Streams in Alabama" (Olin and Bingham, 1982). In that study, a rainfall-runoff model was calibrated for 23 urban drainage basins in Alabama. The model, long-term rainfall data, and observed and synthetic evaporation data were used to synthesize a series of annual peak discharges for each site. The logarithms of the annual peaks were fitted to a Pearson Type III distribution to determine the frequency of peak discharge. Multiple regression equations were developed for estimating peak discharges having recurrence intervals of 2, 5, 10, 25, 50, and 100 years using data from 23 gaging stations in Alabama. Extrapolation techniques (Jennings and others, 1994) were used for the development of the 500-year recurrence interval peak-flow equation. The explanatory variables affecting peak discharge were drainage area and percentage of impervious area. Average standard errors of prediction for the relations in that study ranged from ±24 to ±26 percent. Recurrence interval is the reciprocal of the probability of exceedance and is the average number of years between exceedances for a long period of record.

The May 7, 2003, flood brought a magnitude of flooding and destruction not previously seen in the City of Tarrant (Fire Chief Billy Hewitt, City of Tarrant, oral commun., 2004). The Ketona gage was destroyed prior to the peak. Additionally, the gage at Lawson Road (USGS gage 02456980) (fig. 1) had been deactivated in October 2001. Because of the lack of available streamflow data, an indirect discharge measurement was calculated at Lawson Road. An indirect discharge measurement of 14,100 cubic feet per second (ft^3/s) was used to define the upper end of the stage-discharge relation at the Lawson Road gage (table 1). In order to transfer the computed peak from Lawson Road to the Ketona gage, the peak discharge transfer equation outlined in Atkins (1996) was applied. This method also was used to estimate peak flow at Boyles Gap.

Table 1. Computed peak flows for the May 2003 flood.

[ft, feet; mi^2, square miles; ft^3/s, cubic feet per second]

River station (ft)	Location	Drainage area (mi^2)	Peak flow (ft^3/s)
250	Boyle's Gap	28.4	18,800
13,168	Ketona Gage	23.9	16,700
17,718	Lawson Road	18.6	14,100

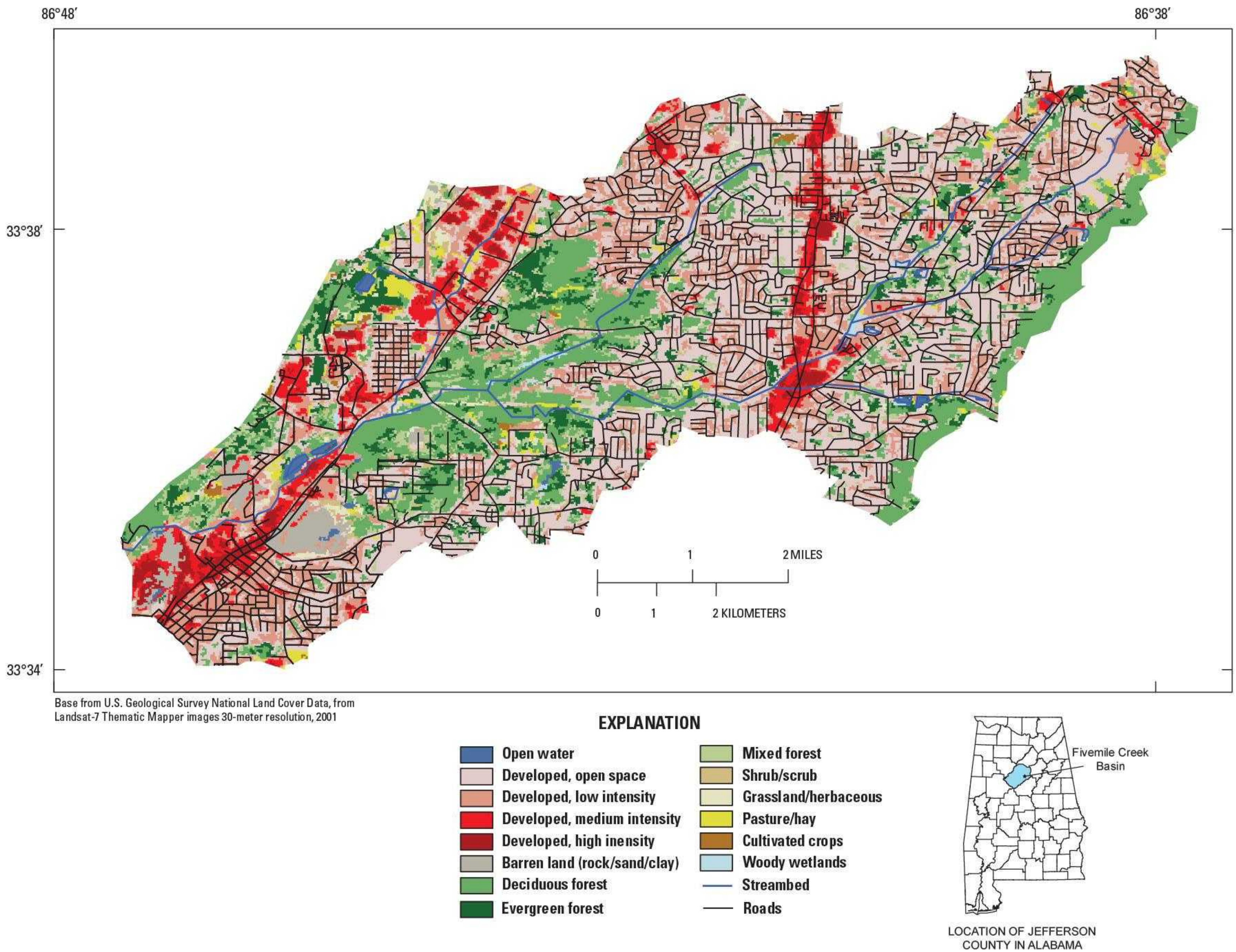

Figure 7. Fivemile Creek basin and associated development.

Using the drainage area, computed impervious area, and methods outlined by Olin and Bingham (1982), the peak flows (table 2) for each sub-reach were computed for selected recurrence intervals. These flows are applicable for current and future flooding potential. The May 7, 2003, peak flows are between the 100- and 500-year recurrence interval.

Hydraulic Modeling

The Hydrologic Engineering Center's River Analysis System (HEC-RAS) (U.S. Army Corps of Engineers, 2002) was selected as the model to simulate flood flow in the Fivemile Creek basin. The HEC-RAS model was used to calculate the water-surface profiles for both gradually and rapidly varied steady flow. The gradually varied flow results of the model are based on the solution of the one-dimensional energy equation. The energy losses considered are those of friction and contraction expansion. The frictional losses are computed using Manning's equation. The contraction expansion losses are computed as a function of the velocity head. In the areas of rapidly varied flow, the momentum equation is used by the model.

Model Calibration

Input data were entered and checked, and then the computational component of the model was used to simulate the May 2003 flood profile. The output showed that the simulated water-surface elevation was higher in some areas than the surveyed flood profile from the May 2003 flood. The methods used to calibrate the model to the known event were: the addition of interpolated cross sections, changes in Manning's roughness coefficients, and the modification of some cross sections to reflect ineffective flow areas.

In order to have improved agreement between the simulated and actual flood profiles, additional cross sections were added. These sections were developed using the "interpolate between cross sections" function in HEC-RAS. After the sections were generated, they were checked for geometric accuracy. Roughness values were assigned to these sections based on aerial photography and field reconnaissance. The original input data also were modified to account for ineffective flow areas by manually blocking the appropriate areas of the cross section. Likewise, roughness values were adjusted slightly to improve the model's agreement with the 2003 flood profile. The computed water-surface profile (table 3) was calibrated

Table 2. Computed peak flows for current conditions

[ft, feet; mi², square miles; ft³/s, cubic feet per second]

River station (ft)	Location	Drainage area (mi^2)	10-year peak flow (ft^3/s)	50-year peak flow (ft^3/s)	100-year peak flow (ft^3/s)	500-year peak flow (ft^3/s)
259	Boyle's Gap	28.1	9,390	13,500	15,700	20,700
13,168	Ketona Gage	23.9	8,340	12,000	13,900	18,300
17,718	Lawson Road	18.6	7,020	10,100	11,700	15,400

Table 3. Difference between observed and computed water-surface profiles for the May 2003 flood

[ft, feet; HEC-RAS, Hydrologic Engineering Center's River Analysis System; see figures 5 and 6 for cross section locations]

River station (ft)	Cross-section identifier	Interpolated observed water-surface elevation (ft)	HEC-RAS computed water-surface elevation (ft)	Difference between observed and computed water-surface elevations (ft)
5,206	D	537.22	537.38	+0.16
6,863	E	542.00	542.10	+0.10
8,692	F	511.37	511.13	-0.24
11,357	G	557.40	557.54	+0.14
13,315	Downstream side of State Highway 79	565.84	565.93	+0.09
14,986	I	567.88	568.09	+0.21
16,798	J	573.53	573.78	+0.25
17,618	100 ft downstream from Lawson Road	576.40	576.61	+0.21
18,068	K	580.50	580.70	+0.20

within 0.25 ft of the observed 2003 flood profile. Points of comparison were based on water-surface elevations interpolated from the surveyed high-water profile, at cross sections above section C (fig. 8).

Simulation of Flood Flows

After the model was successfully calibrated to the 2003 flood, the 10-, 50-, 100-, and 500-year flood flows were simulated. The resulting water-surface profiles reflect the flooding potential for the existing flood-plain conditions and account for future development (fig. 9). Water-surface elevations corresponding to these profiles also were calculated (table 4).

The results indicate that for the 100-year recurrence interval, the flood profile was about 2.5 ft higher, on average, than the profile published in the FEMA (1999) study. The absolute maximum and minimum difference was 6.80 ft and 0.67 ft, respectively. All water-surface elevations computed for the 100-year flood were higher than those published by FEMA, except for cross section H (table 5, fig. 10).

The average flood-plain depth for the 100-year flood was computed for each cross section by dividing the effective flow area by the total width of flow. These depths ranged from 2.4 ft at section H to 11.0 ft at section B (table 6). It should be noted that these are average values based on the flood-plain conditions on either side of the channel (overbank region). The actual depth varies throughout the flood plain based on the local ground-surface elevation. The elevations of the 100-year flood also were compared to the elevations of local roadways and railroads in Tarrant (table 7).

The average top width of flow for the study reach for the 100-year flood was about 800 ft. This value varied from section to section based on the geometry of the flood plain. For instance, the flow at section A (fig. 5), located at Boyles Gap, had a top width of 150 ft. The maximum top width of flow of 2,079 ft occurred just upstream from State Highway 79. This information is provided to show that the average value of top width of flow is averaged for the entire reach and not indicative of every cross section.

Table 4. Computed flood profiles for current conditions.

[ft, feet; —, no data; see figures 5 and 6 for cross-section locations]

River station (ft)	Cross-section identifier	10-year water-surface elevation (ft)	50-year water-surface elevation (ft)	100-year water-surface elevation (ft)	500-year water-surface elevation (ft)
0	Section A	515.84	518.43	519.68	522.24
259	—	516.32	518.58	519.64	521.71
266	L & N Railroad	—	—	—	—
589		518.61	522.15	525.68	534.45
661	—	520.84	525.07	528.36	536.70
1,077	Section B	521.41	525.32	528.50	536.74
2,080	—	522.57	525.45	528.75	536.86
3,030	—	528.92	530.92	531.26	537.17
3,130		529.35	531.13	531.91	537.21
3,131	Ala Power Co. Road				
3,150		531.76	532.53	532.85	537.30
3,280	Section C	531.93	532.81	533.20	537.40
5,266	Section D	533.90	535.49	536.24	538.88
5,288	—	533.83	535.32	536.02	538.56
5,289	L & N Railroad				

Table 4. Computed flood profiles for current conditions.—Continued

[ft, feet; —, no data; see figures 5 and 6 for cross-section locations]

River station (ft)	Cross-section identifier	10-year water-surface elevation (ft)	50-year water-surface elevation (ft)	100-year water-surface elevation (ft)	500-year water-surface elevation (ft)
5,313	—	534.55	537.19	538.70	541.39
5,413		535.09	537.94	539.53	542.68
6,863	Section E	536.13	538.83	540.31	543.33
7,083	—	536.07	538.84	540.35	543.37
7,084	Springdale Road	—	—	—	—
7,111	—	536.84	538.90	540.54	543.44
7,203	—	537.56	539.36	540.78	543.54
7,952	—	538.36	540.06	541.30	543.86
8,692	Section F	541.35	542.46	543.10	544.91
10,000	—	548.63	549.90	550.32	550.90
11,357	Section G	554.82	556.29	556.83	557.94
13,168	Section H	560.79	562.36	562.98	564.20
13,315		561.51	563.19	564.05	566.37
13,316	State Highway 79				
13,430	—	561.84	564.44	565.93	567.49
13,745		563.25	565.85	566.26	567.72
14,986	Section I	565.17	566.75	567.18	568.44
15,898	—	565.25	566.99	567.47	568.86
16,798	Section J	571.22	572.36	572.99	574.07
17,218	—	572.41	573.75	574.41	575.62
17,618		573.93	575.21	575.83	576.97
17,718		573.78	574.78	575.23	575.92
17,719	Lawson Road	—	—	—	—
17,758		575.65	577.84	578.25	578.74
18,068	Section K	577.12	579.38	579.97	581.06

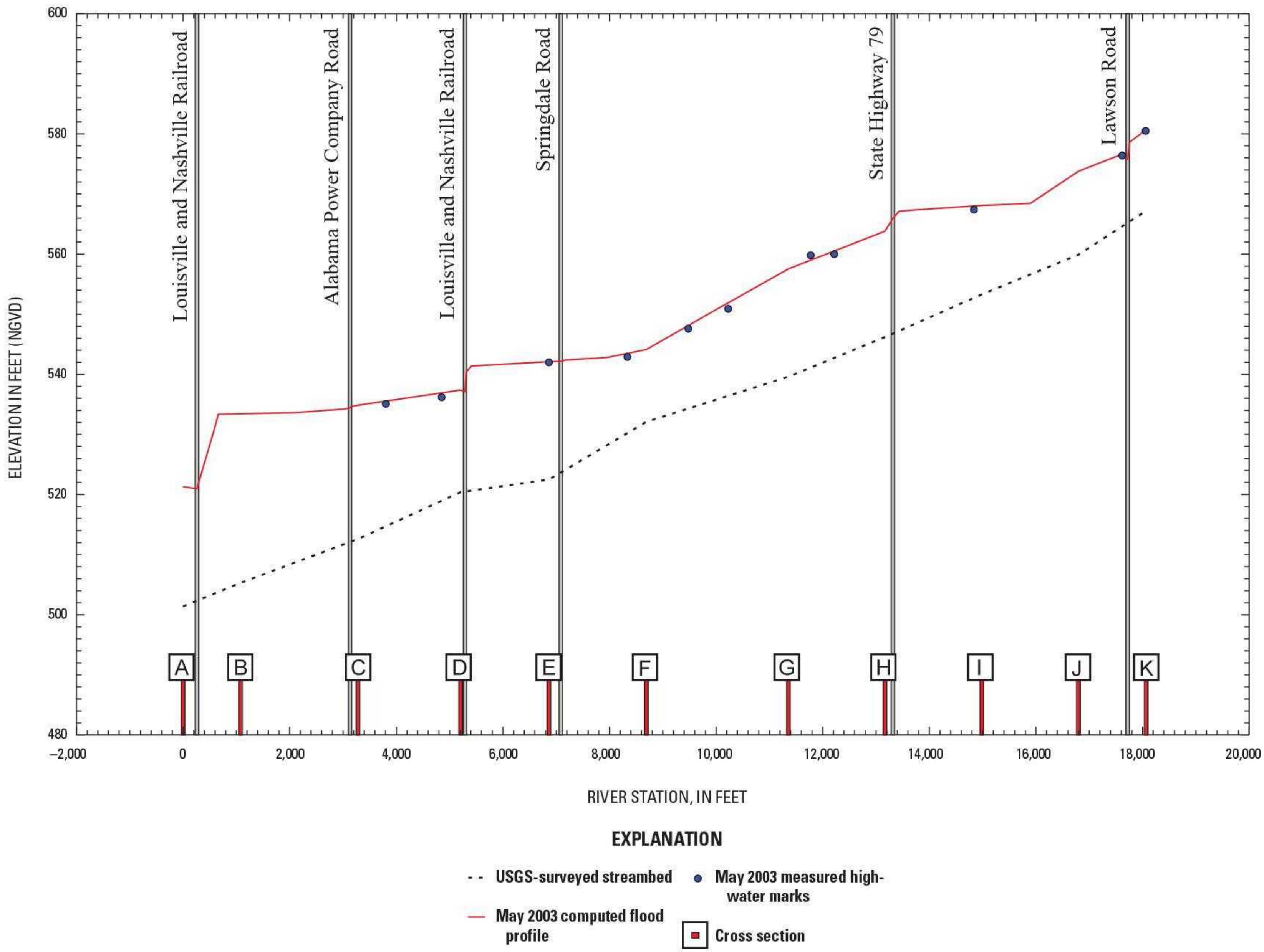

Figure 8. Comparison of computed and actual flood profiles for the May 2003 flood. (See figures 5 and 6 for locations of cross sections.)

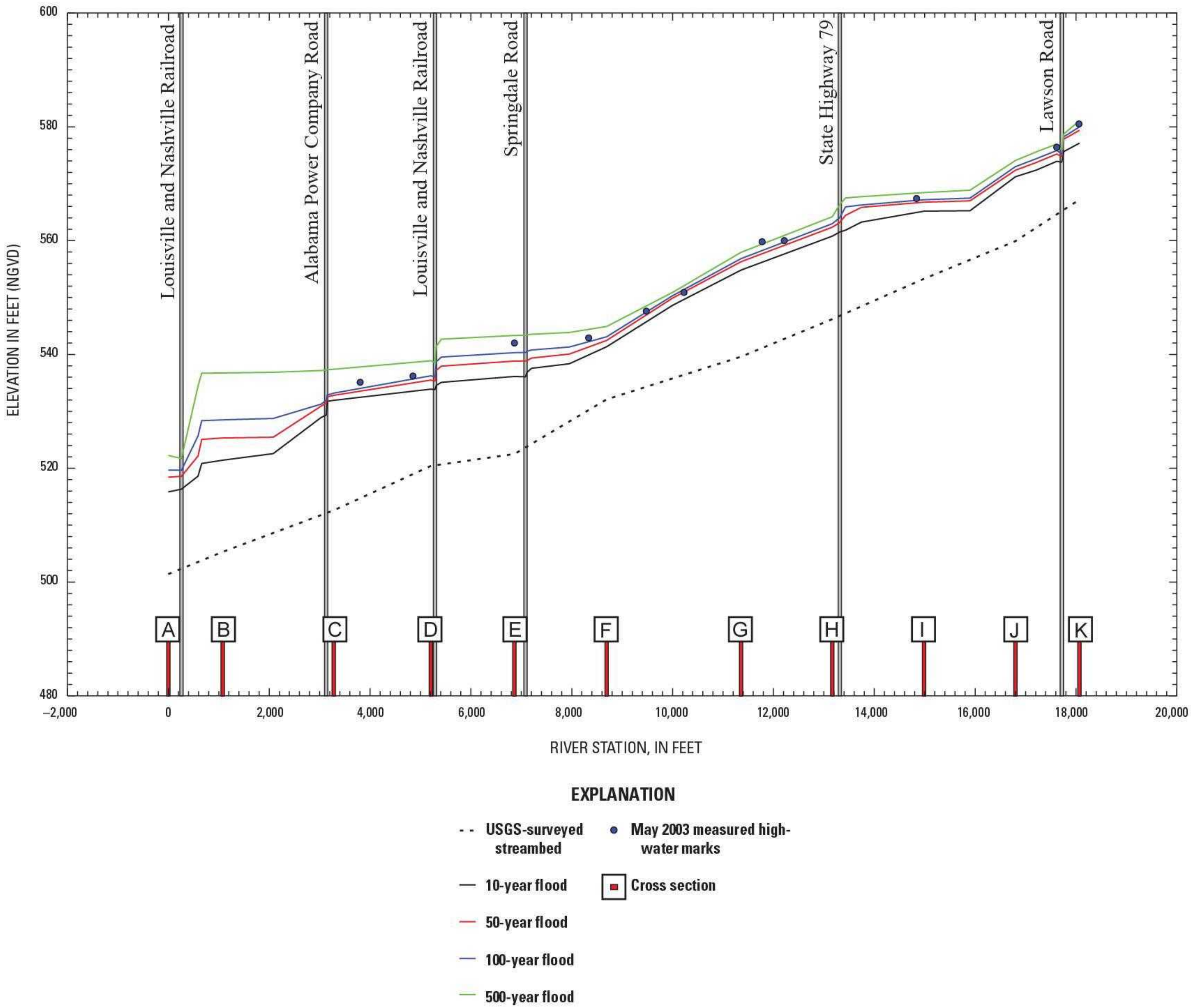

Figure 9. Computed flood profiles for current conditions. (See figures 5 and 6 for locations of cross sections.)

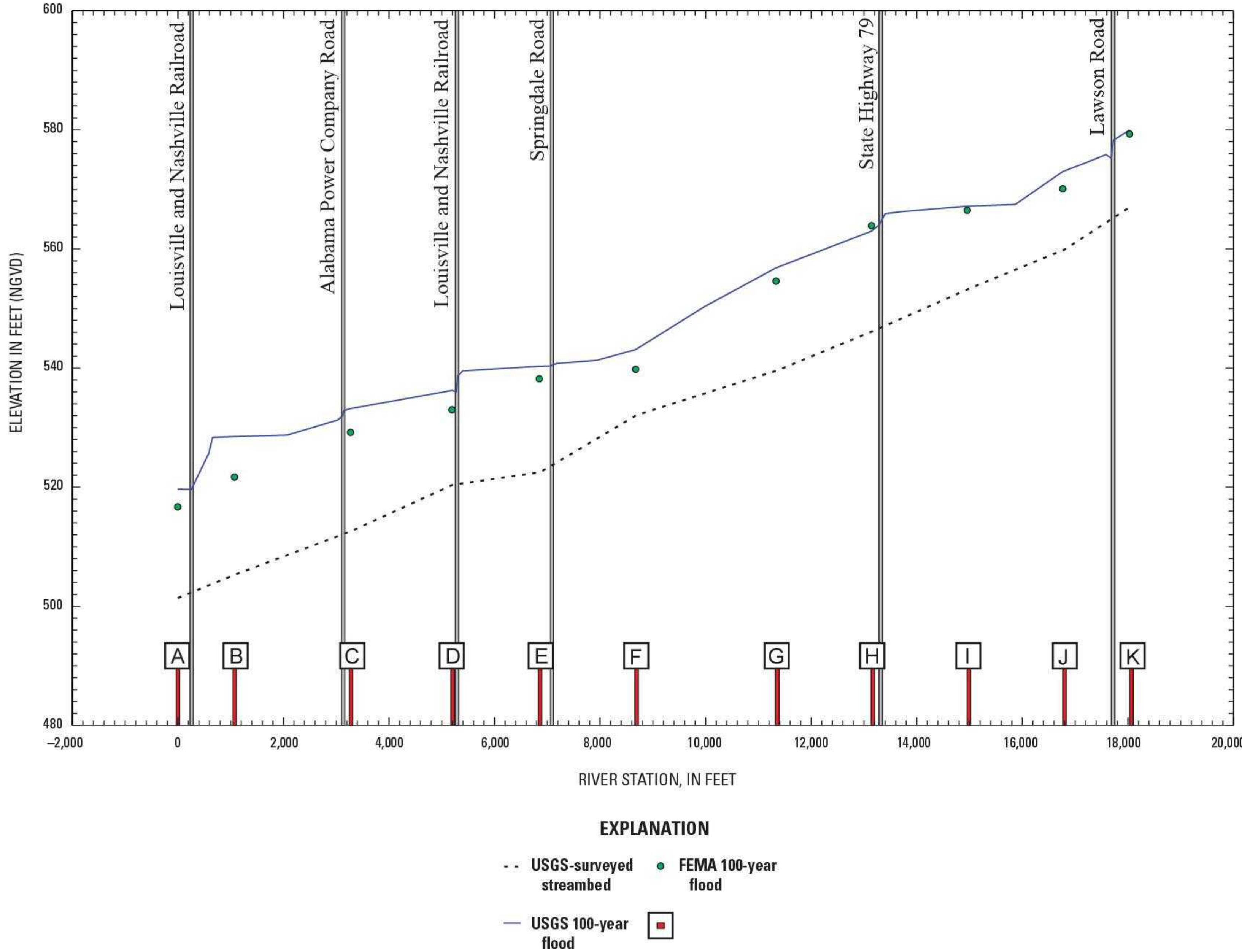

Figure 10. Comparison of U.S. Geological Survey and Federal Emergency Management Agency computed 100-year flood profiles. (See figures 5 and 6 for locations of cross sections.)

Table 5. Comparison of USGS and FEMA computed 100-year flood elevations.

[ft, feet; see figures 5 and 6 for cross-section locations; USGS, U.S. Geological Survey; FEMA, Federal Emergency Management Agency]

River station (ft)	Cross-section identifier	USGS 100-year water-surface elevation (ft)	FEMA 100-year water-surface elevation (ft)	Difference (ft)
0	A	519.68	516.70	2.98
1,077	B	528.50	521.70	6.80
3,280	C	533.20	529.20	4.00
5,206	D	536.24	533.00	3.24
6,863	E	540.31	538.20	−2.11
8,692	F	543.10	539.80	−3.30
11,357	G	556.83	554.60	−2.23
13,168	H	562.98	563.90	−0.92
14,986	I	567.18	566.50	−0.68
16,798	J	572.99	570.10	2.89
18,068	K	579.97	579.30	0.67

Table 6. Average flood-plain depths for 100-year recurrence interval flood.

[ft, feet; see figures 5 and 6 for cross-section locations]

River station (ft)	Cross-section identifier	100-year water surface elevation (ft)	Average hydraulic depth (ft)
0	A	519.68	9.2
1,077	B	528.50	11.0
3,280	C	533.20	3.8
5,206	D	536.24	8.0
6,863	E	540.31	6.7
8,692	F	543.10	3.9
11,357	G	556.83	3.3
13,168	H	562.98	2.1
14,986	I	567.18	7.0
16,798	J	572.99	5.5
18,068	K	579.97	4.3

Table 7. Maximum depth of overtopping for selected roadways and railways.

[ft, feet, no data]

River station (ft)	Roadway crossing in vicinity of bridge	100-year water-surface elevation (ft)	Maximum depth of overtopping (ft)
260	L & N Railroad	525.68	
3,131	Alabama Power Company Road	532.85	3.2
5,289	L & N Railroad	538.70	
7,084	Springdale Road	540.54	3.5
13,316	State Highway 79 Southbound Lane	565.93	2.1
13,316	State Highway 79 Northbound Lane	565.93	5.4
17,719	Lawson Road	578.25	0.8

Summary

A one-dimensional step-backwater model was used to simulate flooding conditions for Fivemile Creek at Tarrant, Alabama. The results of this study provide the community with flood-profile information that can be used for existing flood-plain mitigation, future development, and safety plans for the city. Land use and impervious cover for the basin were calculated using the most recent (2004) aerial photographs available for the reach and the National Land Cover Dataset for 1992 and 2001. The results of the calculations show that in 1992, the basin had about 12 percent impervious area, whereas the 2004 conditions show that the basin had about 20 percent impervious area. In a 12-year period, the percentage of impervious area almost doubled.

Using data collected by the USGS from the May 2003 flood, a flow model was calibrated to match (within 0.25 ft) the recorded event. The calibrated model then was used to simulate flooding for the 10-, 50-, 100-, and 500-year recurrence interval floods. The results indicate that for the 100-year recurrence interval, the flood profile was about 2.5 ft higher, on average, than the profile published by the Federal Emergency Management Agency (FEMA) in 1999. The absolute maximum and minimum difference was 6.80 ft and 0.67 ft, respectively. All water-surface elevations computed for the 100-year flood were higher than those published by FEMA, except for cross section H.

The average flood-plain depth was computed for each cross section based on the effective flow area and the total width of flow for the 100-year flood. These depths ranged from 2.4 ft at section H to 11.0 ft at section B. The results indicate that for the 100-year recurrence interval, overtopping would occur at the Alabama Power Company Road, Springdale Road, State Highway 79, and Lawson Road. The average top width of flow at a given section in the study reach for the 100-year flood was about 800 ft. Top widths of flow in the study reach ranged from about 150 ft at section A to 2,079 ft just upstream from State Highway 79.

References Cited

Atkins, J.B., 1996, Magnitude and frequency of floods in Alabama: U.S. Geological Survey Water-Resources Investigations Report 95-4199, 234 p.

Federal Emergency Management Agency, 1980, Flood insurance study—Tarrant City, Jefferson County, Alabama: Federal Emergency Management Agency, 18 p.

Federal Emergency Management Agency, 1999, Flood insurance study—Jefferson County, Alabama and incorporated areas: Federal Emergency Management Agency, 105 p.

Jennings, M.E., Thomas, W.O., Jr., and Riggs, H.C., 1994, National summary of U.S. Geological Survey regional regression equations for estimating magnitude and frequency of floods for ungaged sites, 1993: U.S. Geological Survey Water-Resources Investigations Report 94-4002, 196 p.

Multi-Resolution Land Characteristics Consortium, 2006, National Land Cover Database 2001, accessed July 19, 2006, at *http://www.mrlc.gov/mrlc2k_nlcd.asp*

Olin, D.A., and Bingham, R.H., 1982, Synthesized flood frequency of urban streams in Alabama: U.S. Geological Survey Water-Resources Investigations Report 82-683, 23 p.

Stamper, W.G., 1975, Flood mapping in Charlotte and Meklenburg County, North Carolina: U.S. Geological Survey Open-File Report, 22 p.

U.S. Army Corps of Engineers, 2002, HEC-RAS river analysis system users' manual, version 3.1: U.S. Army Corps of Engineers, 420 p.

U.S. Geological Survey, 1992, National Land Cover Dataset 1992, accessed December 1, 2005, at *http://landcover.usgs.gov/natllandcover.php*

Appendix. Photographs Showing Locations of Cross Sections

Figure A1. Cross section A, outlet of the box culvert at the L & N Railroad in Tarrant, Alabama. (See figure 5 for location.)

Figure A2. Downstream view of cross section B, in Tarrant, Alabama. (See figure 5 for location.)

Figure A3. Upstream view of the Alabama Power Company Bridge, in Tarrant, Alabama. (See figure 5 for location.)

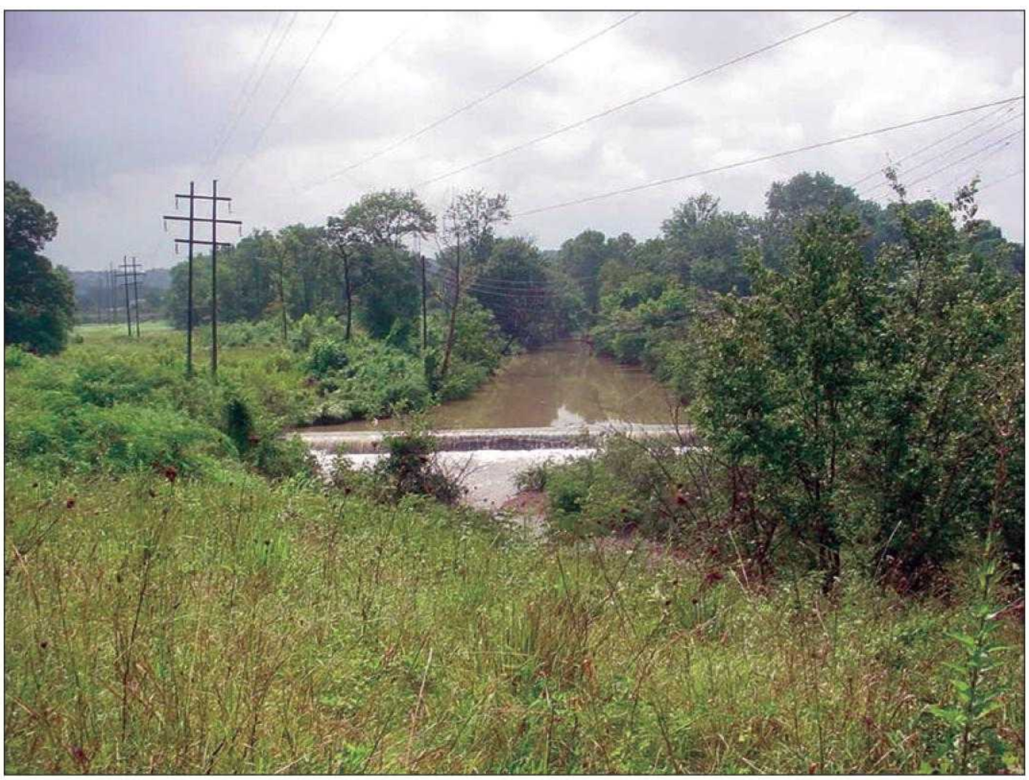

Figure A4. Upstream view of cross section C, in Tarrant, Alabama. (See figure 5 for location.)

Figure A5. Downstream view of cross section D, in Tarrant, Alabama. (See figure 5 for location.)

Figure A6. Upstream view of the Railroad Bridge, in the vicinity of cross section D, in Tarrant, Alabama. (See figure 5 for location.)

Figure A7. Downstream view of cross section E, in Tarrant, Alabama. (See figure 5 for location.)

Figure A8. West overbank of cross section F, in Tarrant, Alabama. (See figure 5 for location.)

Figure A9. Downstream view of cross section H, in Tarrant, Alabama. (See figure 6 for location.)

Figure A10. Upstream view of the State Highway 79 Bridge, in Tarrant, Alabama. (See figure 6 for location.)

Figure A11. Downstream view of cross section I, in Tarrant, Alabama. (See figure 6 for location.)

Figure A12. Upstream view of cross section J, in Tarrant, Alabama. (See figure 6 for location.)

Figure A13. Downstream view of cross section K, in Tarrant, Alabama. (See figure 6 for location.)

Lee and Hedgecock—**Simulation of Flood Profiles for Fivemile Creek at Tarrant, Alabama, 2006**—Open-File Report 2007–1030

Printed on recycled paper